Polymer Derived Ceramic Based Structural Thermal Protection Systems for Atmospheric Entry Vehicles, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The development of robust and efficient Entry, Descent and Landing systems fulfill the critical function of delivering payloads to planetary surfaces through challenging environments. Future NASA missions will require new technologies to further space exploration and delivery of high mass loads. Of particular interest is the development of reusable hot structure technologies for primary structures exposed to extreme heating environments on atmospheric entry vehicles. A hot structure system is a multifunctional structure that can reduce/eliminate the need for a separate thermal protection system. Thus, there is a need for the development of new technologies to support the realization of low-cost, durable/reusable hot structures applicable to atmospheric entry vehicles. A key barrier is the requirement for the lightweight form to not only carry mechanical loads but also accommodate high temperatures (1000-2200°C), severe transient heating, and temperature gradients through the thickness. Novel materials and associated fabrication processes are needed to balance the demand for structural cohesiveness with desired thermal properties required to protect structure interiors. Sporian Microsystems has developed advanced ceramic materials for harsh environments with a particular focus on materials technologies based on ultra-high temperature polymer derived silicon carbonitride (SiCN). The long-term objective of this proposed work is to heavily leverage prior preceramic precursor based insulating materials development, and revise processes that can be used to realize hot structure systems. The PhI effort will focus on assessing candidate processes and SiCN precursor formulation to create relevant load-bearing, insulating structures, then demonstrating technical feasibility by producing and testing hot structure samples. If successful, Sporian will be well prepared for Phase II efforts focused on producing demo units for NASA testing and addressing vehicle integration.

Anticipated Benefits

Thermally/mechanically high temp stable hot structures have many NASA applications due to their ability to improve weight/size, performance of atmospheric entry vehicles, or any vehicle exposed to harsh environments/hypersonic loads. Impacting programs such as HyperX, X-37, Mars Astrobiology Explorer Cacher, Jupiter Europa Orbiter, Uranus Orbiter, and Mars Trace Gas Orbiter, facilitating NASA objectives such as ERA, Advanced Air Vehicles Program, Vehicle Systems Safety Technology, and many more.

Similar to NASA applications, this insulation materials can be used for Department of Defense hypersonic vehicles, missiles, and rockets for programs such as HAWC, HSSW, Falcon Project, HyRAX, Tactical Boost Glide, Boeing Minuteman, Lockheed Martin Trident, Boeing X-51 Waverider, Raytheon SM-3, and other long range stand-off applications. Outside of DoD, applications include oil refineries, power generation structures, incinerators, glass fabrication, degassers, and tundishes to name a few.

Various PDC foam products (top); 2x4x1 inch SiBCN foam panel (bottom) with 100-200 µm pore size (inset).

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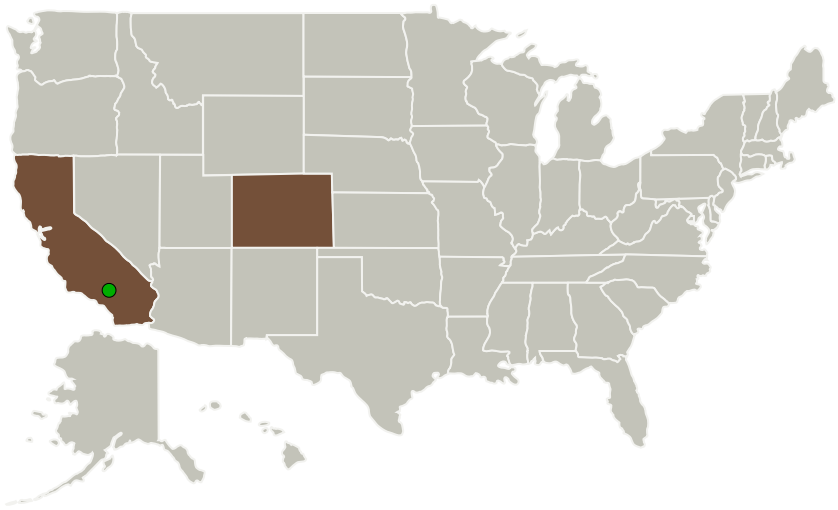
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Sporian Microsystems, Inc.	Lead Organization	Industry	Lafayette, Colorado
Armstrong Flight Research Center(AFRC)	Supporting Organization	NASA Center	Edwards, California

Primary U.S. Work Locations	
California	Colorado

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141232)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Sporian Microsystems, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

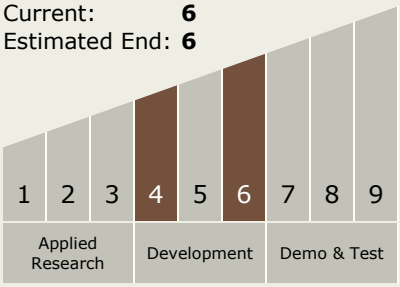
Carlos Torrez

Principal Investigator:

Alexis Jensen

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



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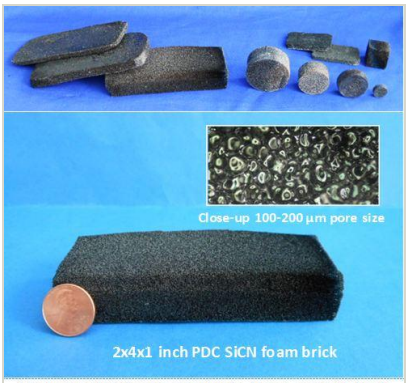
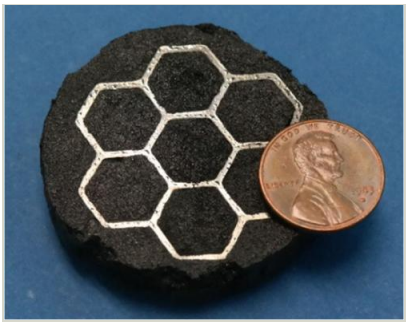
Images



Various PDC foam products (top); 2x4x1 inch SiBCN foam panel (bottom) with 100-200 µm pore size (inset).

Briefing Chart Image
Polymer Derived Ceramic Based Structural Thermal Protection Systems for Atmospheric Entry Vehicles, Phase I
(https://techport.nasa.gov/image/126818)



Final Summary Chart Image
Polymer Derived Ceramic Based Structural Thermal Protection Systems for Atmospheric Entry Vehicles, Phase I
(https://techport.nasa.gov/image/128140)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.6 Materials for Electrical Power Generation, Energy Storage, Power Distribution and Electrical Machines

Target Destinations

Earth, Mars, Others Inside the Solar System